

PROJECT AUTHORIZATION NO. HWY-2004-23

under

MASTER AGREEMENT FOR RESEARCH AND TRAINING SERVICES BETWEEN THE NORTH
CAROLINA DEPARTMENT OF TRANSPORTATION AND
NORTH CAROLINA STATE UNIVERSITY ON BEHALF OF
THE INSTITUTE FOR TRANSPORTATION RESEARCH AND EDUCATION
(Contract No. 98-1783)

Project Title: Monitoring the Effects of Highway Construction Over the Little River and Crane Creek

Formal Statement of Work: See attached proposal

Period of Performance: July 1, 2003 – June 30, 2005

Budget Authorization: \$17,546 (FY 2003-04)
\$16,454 (FY 2004-05)
\$34,000 (TOTAL)

Property to be Furnished by the Department: None

Key Personnel: Daniel Line and Jean Spooner, NCSU Water Quality

Project Monitor: _____

Additional Terms and Conditions: Research Project Guidelines as posted on ITRE's website at
<http://itre.ncsu.edu/research/ongoingguidelines.htm>.

IN WITNESS WHEREOF, the parties hereto have executed this Project Authorization as of
_____, 2003.

NORTH CAROLINA STATE UNIVERSITY NORTH CAROLINA DEPARTMENT
OF TRANSPORTATION

BY: _____
Principal Investigator

BY: _____

BY: _____
N. C. State University

BY: _____
Director of CTE

II. TITLE PAGE

Project Title

Monitoring the Effects of Highway Construction Over the Little River and Crane Creek

Principal Investigators

Daniel Line, PE
Extension Specialist

Jean Spooner
Extension Specialist

Date

June 4, 2003

III. IDENTIFICATION PAGE

Amount of Funds Requested

July 1, 2003 – June 30, 2005: \$34,000

Total: \$34,000

Project Title

Monitoring the Effects of Highway Construction Over the Little River and Crane Creek

Purpose of Proposal

The objectives of this study are to:

- 1) document the changes in the water quality of Crane Creek and the Little River associated with NC DOT's construction of Highway 1.
- 2) evaluate the monitoring data to determine if changes in water quality parameters are significant.

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IV. TABLE OF CONTENTS

Cover Page.....	1
Title Page.....	2
Identification Page	3
Table of Contents.....	4
Statement of Work.....	5
Introduction.....	5
Background.....	5
Problem or Need Definition.....	6
Research Objectives.....	6
Literature or Research Review.....	6
Research Methodology & Tasks.....	7
Significance of Proposed Work.....	9
Implementation & Technology Transfer Plan.....	10
Proposed Work Schedule	10
References.....	10
Biographical Data.....	11
Budget.....	12

V. STATEMENT OF WORK

i. Introduction

Currently under the North Carolina Sedimentation Control Commission rules, runoff leaving a construction site must meet a clarity or turbidity standard of ≤ 50 NTU or the site must have proper and approved best management practices (BMP's) installed and maintained. Sediment from construction sites received public notoriety in North Carolina in 1997 when a plume of red, muddy runoff, thought to be from construction sites, was photographed on its way down the Neuse River. Following this incident, the Governor called on the NC Department of Environment and Natural Resources (NC DENR) to begin stricter enforcement of erosion and sediment control regulations on construction sites. The muddy plume incident and increased public scrutiny has resulted in the need for reliable and defensible documentation of the effectiveness of erosion and sediment control efforts.

One of the most defensible ways to demonstrate the effectiveness of erosion and sediment control programs is through water quality monitoring of surface water resources in close proximity to the construction. The following proposal outlines the monitoring plan for the Little River and Crane Creek in Moore County, NC.

ii. Background

North Carolina has one of the strongest sediment and erosion control programs for construction sites in the U.S. in terms of its comprehensiveness, financing and staffing levels. The program requires anyone who intends to disturb one acre or more of land to have an erosion and sediment control plan detailing the area to be disturbed and measures used to control sediment export from the site throughout the life of the project. Despite an ambitious program, sediment remains the primary pollutant affecting the quality of North Carolina's surface waters. While there are many sources of sediment in the state, construction related activities were cited by the state as a major source of degradation to lakes (NC DENR, 1992). Further, Burby et al. (1990) reported that one-third or more of urban construction sites in the state release sediment to neighboring property and nearby streams.

Sediment from urban areas received public notoriety in North Carolina in 1997 when a plume of red, muddy runoff, thought to be from construction sites, was photographed on its way down the Neuse River. Following this incident, the Governor called on the NC DENR to begin stricter enforcement of erosion and sediment control regulations on construction sites. In addition, the Governor asked for a review of standards and needs for the erosion and sediment control program. One of the identified needs was to develop a better understanding of the limitations and efficiency of erosion and sediment control practices, because very little monitoring data existed on the effectiveness of control practices.

Recently, the Land Quality Section of NC DENR has stated that erosion and sediment control laws will be more strictly enforced. The NC DOT is facing more restrictions on road construction as evidenced by the water quality monitoring requirements for the Interstate 485 construction in Mecklenburg County.

iii. Problem or Need Definition

The need to document, through water quality monitoring, the effectiveness of erosion and sediment control efforts design to minimize sediment loss from construction sites is increasing. This is especially true where highway construction is occurring in close proximity to high quality water resources such as the Little River of Moore County.

iv. Research Objectives

The objectives of this study are to 1) document the changes in the water quality of Crane Creek and the Little River associated with NC DOT's construction of Highway 1 and 2) analyze the monitoring data to determine if changes in water quality parameters are significant.

v. Literature or Research Review

A review of the literature indicates that the sediment trapping efficiency of many devices depends on factors such as the intensity and duration of storm events, topography and extent of construction sites, soil type, and the system of practices implemented. For example, a study which examined the effectiveness of sediment traps and basins found that total suspended solids (TSS) measured in runoff from construction sites ranged up to four times the median value of 680 mg TSS/L for varying storm conditions (Schueler and Lugbill, 1990). These differences in concentrations were shown to effect trapping efficiency of the device. Device trapping efficiency also varies by soil type. Data collected from outflows of sediment trapping devices found instantaneous removal of only 46% of incoming sediment (Schueler and Lugbill, 1990). This low trapping efficiency was partially attributed to the incoming sediment being relatively fine-grained, consisting of silts, clays, and colloidal material (Hainley, 1980; Garcia, 1988; Schueler and Lugbill, 1990).

While there is considerable data on the TSS trapping efficiency of stormwater detention and retention ponds, there is little data on the efficiency of temporary sediment basins located on construction sites and even less on temporary sediment traps. Sediment basins, which are enclosed ponds with a type of riser outlet, have been evaluated by several researchers. A study of sediment basins in the Piedmont region of Maryland documented an average instantaneous TSS removal efficiency of 65% over nine storm events for four basins and two sediment traps (Schueler and Lugbill, 1990). When using only the data from storms that produced outflow, the efficiency decreased to 46%. These data are valuable; however, they were collected for only a limited number of storms and were based on only one sample per event and on only concentrations. More extensive testing at a research site, documented a 93% efficiency on a mass of sediment basis for a basin with a perforated riser and a 94.6% efficiency for the same basin with the addition of flow barriers to the basin (Millen et al., 1996).

The effectiveness of these sediment basins for a variety of soils, storm types, and over a period of time is not well documented, but is thought to be relatively low. So new techniques and modifications to existing practices are being evaluated. For example, using expanded polystyrene chips and gravel as filters enveloped in the spillway in a laboratory-scale sedimentation basin, Engle and Jarrett (1995) achieved average sediment removal of 78.3% and

87.5% for two devices with 1.5 and 3.0 hour de-watering times. Przepiora et al. (1998) found that molding plaster applied at the rate of 350-700 mg/L reduced fine-grained suspended sediment in basins within 3 hours of adding the flocculate. Adding baffles to sediment basins to slow the movement of water may also hold promise for improving their trapping efficiency.

While there has been some research conducted on sediment or TSS trapping efficiency of basins and the effects of modifications of basins, much less is known about the efficiency of temporary sediment traps. Sediment traps are similar to basins in that they are an enclosure for temporarily ponding runoff, but they have a section of the dam made of rocks covered on the upstream side with a layer of wash stones (12-19 mm in diameter) to allow water to pass through. Line and White (2001) monitored two sediment traps on residential construction sites and found their efficiencies ranged from 59-69% during a period of about 18 months. Turbidity of effluent from the traps often exceeded 500 NTU, therefore, the traps were not deemed appropriate for turbidity control.

vi. Research Methodology & Tasks

The efficiencies of erosion and sediment control BMPs often vary with different climatic conditions; however, many times results vary due to poor experimental design or improper or too short a period of monitoring. In this study the experimental design will be upstream/downstream of the area of highway construction and the duration of monitoring will be more than one year. Ideally, monitoring should start prior to construction to determine if there is an inherent increase in pollutant levels downstream; however, since construction has already begun, this is not possible. The duration of monitoring (>1 year) should be long enough for a variety of storm events and a sufficient number of monitored events to allow for statistical analysis of the data.

Site Selection: Many factors including ease of monitoring, representativeness of activities, physiographic region, location, suitability for BMPs, and others effect the selection of monitoring sites. The sites for monitoring have already been determined in general terms- they will be upstream and downstream of the highway construction on Crane Creek and the Little River. More specifically, the sites will be located as close as possible to contributing areas to exclude inputs from nontarget areas and will be in portions of the stream reach, which due to the hydraulics of flow facilitate discharge monitoring and minimize the chance of flooding.

Storm criteria and number: At least initially, all significant storms will be monitored. Significant storms are those that result in at least a 0.03 ft rise in the pre-storm water level. Automated samplers will be programmed to begin sampling or enable after such a rise and continue until the water level falls below the pre-set level. The enable level will be reset upon every visit so that during extended periods of dry or wet weather, approximately the same size storm will enable the sampler. The goal will be to monitor at least 15 storms as in most cases this is the minimum needed to establish a trend through statistical analysis.

Monitoring description: Discharge will be continuously monitored on Crane Creek using automated samplers to monitored water level (stage) and stage-discharge relationships to convert the stage to discharge. Past experience with stormwater runoff monitoring has shown that the use of the Manning formula to compute discharge from water depth measurements often

results in significant error in many cases, therefore, discharges will be measured and not estimated by computations. For the Little River, the ratio of the area of construction to the drainage area of the river, and hence its discharge, appears to be so small that the discharge should not measurably increase between the upstream and downstream stations, thus, discharge measurements are not necessary. Because the discharge is the same upstream and downstream, concentrations or levels can be compared directly rather than having to compute loading rates. Samplers will be programmed to sample hourly following a 0.03 ft rise in the water level for storms and every 3 hours during nonstorm periods.

One composite sample from each storm event will be analyzed unless the event is unusually large in accumulation and duration, then two samples may be analyzed. Additionally, samples of nonstorm discharge will be collected every 3 hours and composited to 1 sampler for 2 weeks in order to assess whether activities in or very near the streambank have any significant effect on water quality. Additionally, a rainfall gage will be installed in the area to obtain total rainfall. The water level will be continuously recorded at all four sites to identify significant storm events.

All samples will be analyzed for total suspended solids (TSS), total solids (TS), and turbidity. Selected samples will also be analyzed for total Kjeldahl nitrogen (TKN), nitrate nitrogen (NO_3), ammonia nitrogen (NH_3), and total phosphorus (TP). Analysis of samples for nitrogen and phosphorus is particularly appropriate during vegetation establishment when fertilizer, mulch, or topsoil may be applied to the area. Samples will be analyzed using standard methods (APHA, AWWA, WPCF. 1989).

Quality assurance/control: Effective quality assurance and control procedures are essential to ensure the utility of monitoring data (U.S. DOT, 1996). Due to the remote locations of the monitoring sites refrigeration is not feasible, therefore acidification of samples will be the only preservation method possible. Samples analyzed for nitrogen and phosphorus will be pre-acidified with sulfuric acid (H_2SO_4) to stabilize the sample until analysis. Samples analyzed for TSS, TS, and turbidity will remain as sample only. Preservation of solids and turbidity is only necessary in rare cases. Samplers will be programmed to collect duplicate aliquots so that each sample can be preserved using appropriate acidification. Sampler tubing will be rinsed and drained prior to collecting a sample.

After collection, samples will be transferred to appropriate laboratory-supplied containers and packed in ice and sent to the laboratory for analysis as soon as possible. An EPA certified laboratory will perform analyses for nitrogen and phosphorus. The analysis of TSS, TS, and turbidity will be conducted by a noncertified laboratory, but will use appropriate procedures and quality control. Sampler blanks and duplicates will be collected and analyzed for the samples collected in the field with at least one blank coming from each sampler. More blanks will be run if significant contamination is found. The laboratory maintains a rigorous quality control program including audits, validations, calibrations, and recover analysis.

Covariates: The extent, general topography, and land use of the drainage area between the upstream-downstream monitoring stations will be determined from maps and observation. Activities, construction phase, degree of imperviousness, and other hydrologic factors occurring on the construction sites will be recorded when observed on our biweekly visits. A record of BMP installation and appearance (i.e stage of vegetation, condition of outlet(s), roads, etc.) will

be also maintained. However, timing of many day-to-day activities such as fertilizer application, seeding, major construction activities will need to be recorded by NC DOT personnel.

Data analysis: Pollutant loads for each significant storm event will be computed from monitoring data. Appropriate statistical analysis of the monitoring data will be conducted. It is likely this will include analysis of variance and possibly nonparametric analyses, if required. The analysis will initially focus on whether the data from the upstream station is significantly different from the downstream station. With a minimum of only 15 storms the probability of obtaining statistically significant results is highly dependent on the variability of the load and effectiveness data. Often, arithmetic effectiveness values of practices are presented without evaluating their statistical significance, which often leads to an erroneous conclusion concerning effectiveness.

Regression of the rainfall-runoff relationship will be developed from monitored data. Pollutant loads for storm events that are missed due to equipment malfunction will be estimated based on rainfall-runoff regression relationships (if runoff data is needed) and pollutant concentrations from monitored storms with characteristics similar to the one missed. Loads from the skipped events may also be estimated using a regression relationship between loads and discharge. This load-discharge relationship is likely to be relatively strong for sediment loading for some periods; however, with relatively rapid construction the land cover often changes too rapidly to maintain a consistent relationship.

vii. Significance of Proposed Work

The results of this research will provide NCDOT with pollutant runoff loads from a highway construction site representative of many highway construction sites. The data will provide NC DOT with an estimate of how effective their sediment and erosion control efforts currently are. Information such as what size and intensity of storm produces sediment and nutrient export and the degree to which highway construction increase peak discharge or overall discharge.

viii. Implementation and Technology Transfer Plan

All sample analysis, rainfall, and runoff data will be compiled in a spreadsheet and will be made available to DOT. Quarterly progress reports will be prepared to indicate progress (i.e number of sites instrumented, storms sampled). Semi-annual reports will include a summary of progress and a list of monitored storms and computed pollutant loads along with storm data such rainfall amounts and peak runoff rates. A final comprehensive report including site characterization, hydrologic, pollutant load data will be compiled. The reports will not be presentation quality (not desktop published), but will be clearly legible and well organized.

The project team will review the NC DOT's guidelines for monitoring highway construction, written by Ronald Sneed and suggest additions/changes based on experience and the information gained from this and other studies.

ix. Proposed Work Schedule

The duration (24 months) of the study allows for the sufficient data, assuming normal rainfall occurs, can be collected provided all sites are instrument simultaneously. The following is an

anticipated schedule from the time the study is funded.

<u>Task</u>	<u>Time to from start</u>
Select sites and characterize	month 1
Instrument sites (4 sites)	month 1
Semi-annual report	month 6
Semi-annual report	month 12
Complete monitoring of site	months 18-20
Semi-annual report	month 18
Data analysis	month 22
Submit final report	month 24

x. References

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xi. Biographical Data

See attached resumes.